



(12) **EUROPEAN PATENT APPLICATION**
 published in accordance with Art. 158(3) EPC

(43) Date of publication:
 10.09.2003 Bulletin 2003/37

(51) Int Cl.⁷: H04R 1/28, H04R 9/10,
 H04M 1/02, H04M 1/03

(21) Application number: 02772922.7

(86) International application number:
 PCT/JP02/09926

(22) Date of filing: 26.09.2002

(87) International publication number:
 WO 03/028404 (03.04.2003 Gazette 2003/14)

(84) Designated Contracting States:
 AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
 IE IT LI LU MC NL PT SE TR

(72) Inventors:
 • KONISHI, Shuhei
 Yao-shi, Osaka 581-0018 (JP)
 • ANDO, Kimihiro
 Tsu-shi, Mie 514-0817 (JP)

(30) Priority: 26.09.2001 JP 2001293804
 20.11.2001 JP 2001354499
 20.02.2002 JP 2002043022
 01.07.2002 JP 2002191900

(74) Representative: Grünecker, Kinkeldey,
 Stockmair & Schwanhäusser Anwaltssozietät
 Maximilianstrasse 58
 80538 München (DE)

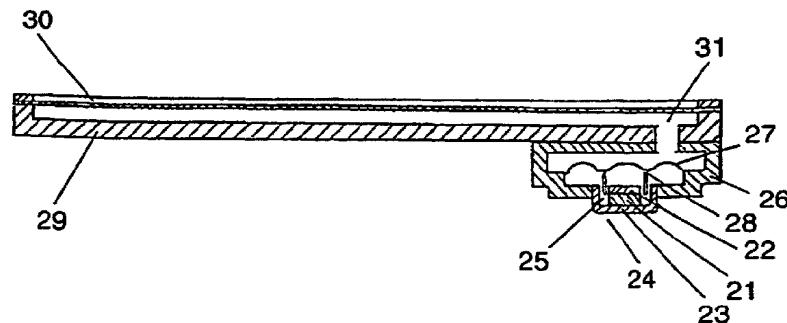
(71) Applicant: MATSUSHITA ELECTRIC INDUSTRIAL
 CO., LTD.
 Kadoma-shi, Osaka 571-8501 (JP)

(54) **SPEAKER, SPEAKER MODULE, AND ELECTRONIC EQUIPMENT USING THE SPEAKER MODULE**

(57) A loudspeaker comprising an enclosure 31 provided with a second diaphragm disposed at an opening, and at least one sound generator 40 coupled acoustically with the enclosure. The sound generator is provided with a first diaphragm 27, wherein the second diaphragm has an area greater than an area of the first di-

aphragm. In the present invention, shape of the enclosure, positioning and shape of the first and the second diaphragms can be designed at a designer's option. Thus a small-sized electronic apparatus can be obtained with a greater designing freedom, while a large-sized diaphragm prevents a decrease of generated sound pressure.

FIG. 2



Description

TECHNICAL FIELD

[0001] The present invention relates to a loudspeaker, a loudspeaker module using the loudspeaker and an electronic apparatus such as a portable telephone unit, a communication apparatus, a game unit or the like, using the loudspeaker or the loudspeaker module.

BACKGROUND ART

[0002] A conventional technology is described referring to FIGs. 20 - 22.

[0003] FIG. 20 is a cross sectional view of a conventional loudspeaker, FIG. 21 is a cross sectional view in part of a portable telephone unit showing a state where the loudspeaker is mounted therein.

[0004] Referring to FIG. 20, a magnetized magnet 1 is sandwiched by an upper plate 2 and a yoke 3 to form a magnetic circuit 4, and a frame 6 is connected to the yoke 3 of magnetic circuit 4. A diaphragm 7 coupled with a voice coil 8 is adhered and fixed on the circumference of frame 6 so that the voice coil 8 is inserted in a magnetic gap 5 of magnetic circuit 4.

[0005] FIG. 21 and 22, respectively, show a state where a conventional loudspeaker 10 is mounted in a portable telephone unit. A display device 12 is disposed in the outer case 11 of portable telephone unit, and a loudspeaker 10 is disposed on a reverse surface of an outer case, or a surface opposite to the display device 12. An operation section 13 is disposed besides the display device 12. Furthermore, a receiver 14 is provided next to the display device 12.

[0006] In the recent requirements towards small-sized and multi-functioning of the portable telephone units and other electronic appliances, the loudspeaker 10 is also requested to be still more downsized, and to have a greater freedom in the mounting disposition. It is essential to make an area of the diaphragm 7 smaller if a loudspeaker 10 is to be downsized; however, a diaphragm 7 having a reduced area accompanies a problem of reduced sound pressure level.

[0007] Among the compact-sized portable telephone units, some are further requested to be compatible with stereo-phonic signals; then a telephone unit needs to be mounted with a plurality of loudspeakers 10. In such a case, the loudspeaker 10 is requested to become more compact.

[0008] The present invention addresses to provide a loudspeaker that contributes to a further downsizing of the electronic apparatus such as a portable telephone units and the like.

DISCLOSURE OF THE INVENTION

[0009] A loudspeaker of the present invention comprises an enclosure having a second diaphragm dis-

posed at an open end, and at least one sound generator acoustically coupled with the enclosure. The sound generator is provided with a first diaphragm, and an area of the second diaphragm is greater than an area of the first diaphragm. Depending on needs, the second diaphragm is divided into portions and the divided portions are connected with a flexible material, and the thickness of the second diaphragm can be varied depending on a portion.

10

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

15 FIG. 1 is a cross sectional view of a loudspeaker in accordance with an exemplary embodiment of the present invention.

20 FIG. 2 is a cross sectional view of a loudspeaker in accordance with other exemplary embodiment of the present invention.

25 FIG. 3 is a cross sectional view of a portable telephone unit mounted with the loudspeaker of FIG. 2. FIG. 4 is a cross sectional view of a portable telephone unit in accordance with an exemplary embodiment of the present invention.

30 FIG. 5 is a cross sectional view of a loudspeaker in accordance with another embodiment of the present invention.

35 FIG. 6 is a cross sectional view of a loudspeaker in accordance with still another embodiment of the present invention.

40 FIG. 7 is a cross sectional view of a module in which the loudspeaker of FIG. 6 and a display device are integrated.

45 FIG. 8 is a cross sectional view of a portable telephone unit incorporating the module of FIG. 7.

50 FIG. 9 is a cross sectional view of a loudspeaker in accordance with yet another embodiment of the present invention.

55 FIG. 10(a) is a cross sectional view of a loudspeaker in accordance with still other embodiment of the present invention.

55 FIG. 10(b) is a cross sectional magnified view showing a key portion of FIG. 2(a).

55 FIG. 11 is a cross sectional view of a loudspeaker in accordance with still other embodiment of the present invention.

55 FIG. 12 is a cross sectional view of a module in which the loudspeaker of FIG. 10 and a display device are integrated.

55 FIG. 13 is a cross sectional view of a loudspeaker in accordance with still other embodiment of the present invention.

55 FIG. 14(a) is a cross sectional view of a loudspeaker in accordance with still other embodiment of the present invention.

55 FIG. 14(b) is a cross sectional magnified view showing a key portion of FIG. 14(a).

FIG. 15(a) is a cross sectional view of a loudspeaker in accordance with still other embodiment of the present invention.

FIG. 15(b) is a cross sectional magnified view showing key portions of FIG. 15(a).

FIG. 15(c) is a cross sectional magnified view showing key portions of FIG. 15(a).

FIG. 16 is a cross sectional view of a loudspeaker in accordance with still other embodiment of the present invention.

FIG. 17 is a cross sectional view of a loudspeaker in accordance with still other embodiment of the present invention.

FIG. 18(a) is a cross sectional view of a module in accordance with an exemplary embodiment of the present invention.

FIG. 18(b) is a cross sectional magnified view showing key portions of FIG. 18(a).

FIG. 19(a) is a cross sectional view of a portable telephone unit in accordance with an exemplary embodiment of the present invention.

FIG. 19(b) is a cross sectional magnified view showing key portions of FIG. 19(a).

FIG. 20 is a cross sectional view of a conventional loudspeaker.

FIG. 21 is a cross sectional view of a conventional portable telephone unit.

FIG. 22 is a cross sectional view of another conventional portable telephone unit.

BEST MODE FOR CARRYING OUT THE INVENTION

[0011] Now in the following, exemplary embodiments of the present invention will be described with reference to the drawings.

First Embodiment

[0012] FIG. 1 shows a cross sectional view of a loudspeaker in accordance with an exemplary embodiment of the present invention.

[0013] A loudspeaker in the first exemplary embodiment comprises a box 29 provided at the opening with a substantially flat second diaphragm 30, and a sound generator 40.

[0014] The sound generator 40 comprises an inner magnet type magnetic circuit 24 with a magnetized magnet 21 sandwiched by an upper plate 22 and a yoke 23. A frame 26 is connected to the yoke 23 of magnetic circuit 24, a first diaphragm 27 is bonded to the circumference of the frame 26, and the first diaphragm 27 is coupled with a voice coil 28. The voice coil 28 is inserted in a magnetic gap 25 of the magnetic circuit 24.

[0015] A box 29 is connected to the circumference of the frame 26, and the box 29 is provided with a substantially flat second diaphragm 30 bonded to the opening of the box 29. The first diaphragm 27 and the second diaphragm 30 are acoustically coupled via an enclosure

31. Area of the second diaphragm 30 in the present embodiment is greater than that of the first diaphragm 27.

[0016] In a structure in accordance with the present invention, a shape of the enclosure 31 as well as positioning and a shape of the first and the second diaphragms can be designed at a designer's option. Thus a designer will have a greater designing freedom in producing a compact portable telephone unit, while evading a degradation in the sound pressure of reproduced sound with a use of a larger-sized diaphragm.

[0017] In the above description, the sound generator 40 is described based on a dynamic electro-acoustic transducer. However, the sound generator 40 is not limited to the dynamic electro-acoustic transducer; it can be an electrostatic transducer or a piezoelectric transducer.

[0018] The second diaphragm 30 may have a thickness of 0.05 - 10 mm, depending on a total size of the apparatus. Thus a portable telephone unit or the like equipment can be designed to have a thinner profile.

[0019] A gap size underneath the second diaphragm 30 may be 0.01 - 10 mm. Thus a portable telephone unit or a larger equipment can be designed to provide a still thinner profile.

[0020] Although in the above description the box 29 and the frame 26 have been explained as discrete members, these components may be provided as an unitary body by a resin molding or the like processes. In this case, a finished sound generator provided in advance by coupling a diaphragm with a magnetic circuit 24, may be fit to the integrated resin body at a place corresponding to the frame.

Second Embodiment

[0021] A loudspeaker in accordance with a second exemplary embodiment of the present invention is described referring to FIG. 2. The point of difference as compared with that in the first exemplary embodiment is that the frame 26 is disposed at an end portion of the box 29. In the above-described configuration in accordance with the present exemplary embodiment, the first diaphragm 27 can be disposed at a portion corresponding to an end part of the second diaphragm 30 by making use of the enclosure 31. Thus it provides a still larger designing freedom, and a portable telephone unit having a large second diaphragm 30 can be provided in a still reduced overall dimension.

[0022] Furthermore, according to the present exemplary embodiment, a specific area among the outer surfaces of an electronic apparatus can be utilized as the second diaphragm 30. Thus highly efficient designing of an electronic apparatus can be expected.

Third Embodiment

[0023] A loudspeaker in accordance with a third exemplary embodiment is described in the following. The

point of difference as compared with the first exemplary embodiment is that the second diaphragm 30 and the box 29 in the present exemplary embodiment are made of a transparent material. As a result, according to the present embodiment, the second diaphragm 30 as well as the box 29 can be seen through to the their bottom or the back. When designing, for example, a portable telephone unit in the above-described configuration, a display device or the like components can be disposed at an efficient space factor. In other words, they can be disposed not only in the surface area next to a loudspeaker or second diaphragm 30, but they can be also disposed in a space behind the loudspeaker or the second diaphragm 30. Thus, a still larger designing freedom and a portable telephone unit having a large second diaphragm 30 can be obtained in a more compact contour.

Fourth Embodiment

[0024] FIG. 3 is a partial cross sectional view of a portable telephone unit incorporating a loudspeaker provided in accordance with the second exemplary embodiment of the present invention.

[0025] Referring to FIG. 3, a module 50 comprising a display device 41 and a loudspeaker of the second embodiment is mounted in a portable telephone unit. A diaphragm 30 and a box 29 of the loudspeaker in the present embodiment are made of a transparent film and a transparent resin. In the present exemplary embodiment, a display device 41 is disposed in a space underneath the diaphragm 30 and the box to form an integrated module. The transparent diaphragm 30 and the transparent box 29 enable the present module. Thus, a still larger designing freedom and a portable telephone unit having a large second diaphragm 30 can be obtained in a more compact contour.

[0026] An integration of a loudspeaker and a display device into module leads to a reduced number of processing steps during production, and to an effective parts supply management. These eventually contribute to a cost reduction.

Fifth Embodiment

[0027] A sixth exemplary embodiment is described with reference to FIG. 4. FIG. 4 is a partial cross sectional view of a portable telephone unit 51 incorporating a module 50 described the fourth exemplary embodiment.

[0028] Referring to FIG. 4, key portion of the portable telephone unit 51 comprises the module 50 and an operation section 42, both of them connected and housed in an outer case 52. Disposing the operation section 42 next to the module 50 enables downsizing of a portable telephone unit 51, and increases the designing freedom.

[0029] Furthermore, it is also possible to dispose both the display device 41 and the operation section 42 in a space underneath the transparent second diaphragm

30. Thus further downsizing and a larger designing freedom of a portable telephone unit 51 can be expected.

[0030] Although the above description in the present exemplary embodiment has been made based on a portable telephone unit, the concept can be applied to, besides portable telephone unit, various kinds of electronic apparatus such as every kinds of communication equipment, a game unit, a Liquid Crystal TV receiver, a personal computer, a navigation device, and the like.

10

Sixth Embodiment

[0031] A loudspeaker in accordance with a sixth exemplary embodiment of the present invention is described referring to FIG. 5. In the present exemplary embodiment, two sound generators 40 are provided at both end portions of the box 29 (second diaphragm 30) of the second exemplary embodiment. The disposition of the two first diaphragms 27 in an opposing arrangement at

20 both ends of the diaphragm 30 leads to a further downsizing of a portable telephone unit having a large-size diaphragm 30, and to a larger designing freedom.

[0032] Like in the third exemplary embodiment, the above configuration allows a designer a freedom to design a shape of the enclosure 31, where a shape and locations of the respective diaphragms can be designed at a designer's option. For example, when the sound generators 40 are disposed with a long distance between each other, as shown in FIG. 6, it effectively reduces cross talk between the right and the left channels in receiving stereophonic signals.

[0033] As is understood from the above description, area of the diaphragm 30 in the present preferred embodiment is greater than at least double the area of diaphragm 27 of the sound generator 40.

[0034] Thus the sound pressure of a loudspeaker is increased by the use of a large-sized diaphragm 30 and a plurality of sound generators 40. Since the space between the sound generators can be utilized by other components effectively, the compactness is not sacrificed and a loudspeaker can provide a great sound pressure in accordance with the present preferred embodiment.

[0035] The above explanation is made about an example using two sound generators, but the number of sound generator is not limited to two. For example, a diaphragm 30 may be provided with four sound generators disposed around, and one among a plurality of sound generators may be used for a buzzer, and many other modifications may be developed. When a plurality of sound generators are used, the size of individual sound generator can be reduced, which contributes to a further downsizing of an apparatus.

55 **Seventh Embodiment**

[0036] A module in accordance with a seventh exemplary embodiment of the present invention is described

with reference to FIG. 7. In the present exemplary embodiment, a loudspeaker in the sixth exemplary embodiment comprising a transparent second diaphragm 30 and a transparent box 29 is integrated with a display device 41 into a module 60. The diaphragm 30 is disposed in the front and covering the display device 41. The modular component is advantageous in reducing the number of process steps during assembly of an electronic apparatus and effective components supply management. This leads to a reduced cost.

[0037] The module 60 in the present preferred embodiment can be mounted in an outer case 52, as shown in FIG. 8, to produce a portable telephone unit 51. The portable telephone unit 51 comprises at least a module 60 and an operation section 42. The use of a module 60 contributes to reduce the overall size, to thin and to provide more designing freedom with the portable telephone unit 51.

[0038] A loudspeaker module 50 may be disposed in any layouts in accordance with a function and a design, such as in a lengthwise arrangement or in a lateral arrangement in the outer case 52 of portable telephone unit 51.

[0039] Furthermore, both of the display device 41 and the operation section 42 can be disposed in a space underneath the transparent diaphragm 30. This arrangement enables a further downsizing of a portable telephone unit 51 and provides a further increased designing freedom. The operation section 42 can be operated by giving a pressing force with a finger, for example, from above the transparent second diaphragm 30.

[0040] In a structure of the present embodiment, a diaphragm 30 can be shared by a receiver, which used to be provided independently. In this configuration, a receiver sound-hole which used to be an indispensable item can be eliminated to provide a remarkably improved waterproof or drip-proof property. In addition, a broad vibration area of the large-sized diaphragm provides a wider service area.

[0041] Although the above explanation has been made based on a portable telephone unit, the concept can be applied to, besides portable telephone unit, various kinds of electronic apparatus such as a communication equipment, a game unit, an LCD TV receiver, a personal computer, a navigation device and the like.

Eighth Embodiment

[0042] An eighth exemplary embodiment of the present invention is described with reference to FIG. 9. In FIG. 9, a second diaphragm 30 of the third exemplary embodiment is divided into two portions at substantially the middle, and two portions are connected with a flexible material 33. This configuration contributes to an improved channel separation at stereophonic sound reproduction.

[0043] Namely, with the diaphragm 30 of the embodiment 3, sounds generated from the two sound genera-

tors are sometimes mixed together causing a cross talk. This often affects the channel separation at stereophonic sound reproduction to a deteriorated stereophonic atmosphere. However, the second diaphragm 30 in accordance with the present exemplary embodiment, which is divided into two portions at substantially the middle, provides an improved channel separation during stereophonic sound reproduction.

[0044] As to the material 33 for dividing a diaphragm 30 into two portions, a silicone resin, a rubber, a thermoplastic elastomer, a foamed resin and the like may be used. Silicone resin has a superior waterproof property, and provides a stable channel separation during sound reproduction in stereo channel under a wide temperature range. Rubber materials provide a designer with a broad selection range in the flexibility. Thus, rubber is suitable when a critical adjustment of channel separation is requested. Thermoplastic elastomer is advantageous in high productivity and a reduced cost.

[0045] Foamed resin has a great internal loss, which leads to a remarkable channel separation effect.

[0046] When the sound generators 40 are disposed with a large distance between each other as illustrated in FIG. 10, cross talk between the right and left channels can be further reduced to a still improved channel separation during stereo sound reproduction.

[0047] When the sound generators 40 are disposed, as shown in FIG. 11, so that a center of each sound generator 40 coincides with a center of respective divided portions of diaphragm 30 divided at the middle, vibration of diaphragm 27 can be sent precisely to the corresponding right-left portions of the diaphragm 30. As a result, the unwanted resonance of diaphragm 30 is reduced, and a low distortion and a high-fidelity reproduction of the sound are performed. Although the above description has been made on a diaphragm 30 divided into two portions, a diaphragm may be divided into three or more portions and each of the portions may be provided at a center of an individual diaphragm 27 of the sound generators 40. Thus the concept can be applied to a diaphragm divided into an increased number of portions.

[0048] Furthermore, when a transparent material is used for the material 33 and the second diaphragm 30 is made of a transparent film, a display device 41 can be disposed underneath the diaphragm 30 without inviting visual hazard. Thus, the loudspeaker of the present exemplary embodiment and the display device 41 can be integrated into a module 70.

[0049] An integration of a loudspeaker and a display device into module contributes to reduce a number of process steps during the production, and to an effective parts supply management. These lead to a reduced cost.

Ninth Embodiment

[0050] A ninth exemplary embodiment of the present invention is described with reference to FIG. 13.

[0051] FIG. 13 illustrates a loudspeaker of the first exemplary embodiment wherein a thickness of the second diaphragm 30 differs depending on a portion. A loudspeaker in the present embodiment has a diaphragm 30, which has a thin groove area A at an outer circumference. Vibration mode of the diaphragm 30 is adjustable by changing its partial thickness. Thus, the sound pressure /frequency characteristic and the distortion characteristic can be controlled to produce favorable characteristics.

[0052] Namely, the loudspeaker in the first exemplary embodiment has a difficulty in controlling the vibration mode of diaphragm 30 in some cases, and the frequency characteristics sometimes become unstable. With the structure of the present exemplary embodiment, however, the vibration mode can be controlled by changing partial thickness of the diaphragm 30. As a result, a compact loudspeaker yet having superior frequency characteristic and distortion characteristic is produced.

[0053] Also in the present exemplary embodiment, the channel separation at stereo sound reproduction can be improved by providing a long distance between the first diaphragms 27 disposed right and left as shown in FIG. 14.

[0054] The second diaphragm 30 may be further provided with grooves 34, as shown in FIG. 15. The grooves 34 suppress propagation of vibration to change the vibration mode. The frequency characteristic and the distortion characteristic can also be put under a finer control by making use of the grooves 34. The resultant effects include, a reduced unnecessary resonance of diaphragm 30, a lower distortion, a high fidelity sound reproduction, and so on, which integrally lead to further improved frequency characteristics.

[0055] It is preferred that the grooves 34 are carefully provided to halfway of the material thickness of diaphragm 30 in order not to introduce air leakage.

[0056] Furthermore, the vibration mode of diaphragm 30 can be optimized by gradually increasing its thickness from a center to an outer periphery, as shown in FIG. 16. Namely, the thinned material thickness of diaphragm 30 at the central area and the vicinity reduces mass of the diaphragm, which improves the sound pressure level at high frequency range and extends the frequency limit at high frequency range. The thickness in the intermediary region is kept normal, and that at the outer periphery is increased to optimize the total weight balance of the diaphragm to reproduce the sound favorably down to a low frequency range.

[0057] Contrary to the above-described configuration, material thickness of the diaphragm 30 can be thinned gradually from the central area towards the outer periphery as shown in FIG. 17. The greater mass in the central

area makes the vibration mode of a diaphragm 30 as that of a high-cut filter. Thus a sound of a middle- and high-frequency range are cut off and a heavy low sound can be reproduced.

[0058] Further, a display device 41 and a loudspeaker in the present embodiment can be integrated into a module 80, as shown in FIG. 18, in the same way as in the foregoing exemplary embodiments. This configuration provides a further downsizing and designing freedom with an electronic apparatus, as well as improved frequency characteristics. In a diaphragm 30 of FIG. 18, a thin groove areas A are provided as shown in FIG. 18 (b), for controlling the frequency characteristics.

[0059] The module 80 is built in a portable telephone unit or other electronic apparatus, as shown in FIG. 19. The module 80 enables to reduce the number of process steps during production and to simplify the parts supply management, while maintaining favorable frequency characteristics of an electronic apparatus. Thus, the module 80 eventually lead to a cost reduction.

INDUSTRIAL APPLICABILITY

[0060] A loudspeaker in the present invention comprises an enclosure having a second diaphragm disposed at an open end, and at least one sound generator coupled acoustically with the enclosure. The sound generator has a first diaphragm, and the second diaphragm is characterized in that it has a greater area than that of the first diaphragm. The present invention allows a free optimization of respective diaphragms in terms of the positioning and shape, and downsizes a loudspeaker module and a portable electronic apparatus. Furthermore, the present invention provides an improved channel separation at stereo sound reproduction by a compact apparatus.

Claims

- 1.** A loudspeaker comprising:
an enclosure having an opening provided with a second diaphragm disposed at said opening; and
at least one sound generator provided with a first diaphragm and coupled acoustically with said enclosure,
wherein, said second diaphragm has an area greater than an area of said first diaphragm.
- 2.** The loudspeaker of claim 1, wherein said sound generator is one selected from the group consisting of an dynamic electro-acoustic transducer, an electrostatic electro-acoustic transducer and a piezoelectric electro-acoustic transducer.

3. The loudspeaker of claim 1, wherein the area of said second diaphragm is not less than twice than the area of said first diaphragm.

4. The loudspeaker of claim 1, wherein a material thickness of said second diaphragm is 0.05 - 10 mm.

5. The loudspeaker of claim 1, wherein a gap size of said enclosure beneath said second diaphragm is 0.01 - 10 mm.

6. The loudspeaker of claim 1, wherein said first diaphragm is disposed at a portion corresponding to an end portion of said second diaphragm.

7. The loudspeaker of claim 1, wherein both of said second diaphragm and said enclosure are made of a transparent material.

8. The loudspeaker of claim 4, wherein said transparent material is a resin.

9. The loudspeaker of claim 1, wherein said enclosure and a frame of said sound generator are unitary molded.

10. The loudspeaker of claim 1, wherein said second diaphragm is divided into portions, said portions being connected via a flexible material.

11. The loudspeaker of claim 1, wherein said first diaphragm is disposed at substantially a center of respective divided portions of said second diaphragm.

12. The loudspeaker of claim 10, wherein said flexible material is transparent.

13. The loudspeaker of claim 10, wherein said flexible material is one selected from the group consisting of a silicone resin, a rubber, a thermoplastic elastomer and a foamed resin.

14. The loudspeaker of claim 1, wherein a material thickness of said second diaphragm differs depending on a portion.

15. The loudspeaker of claim 14, wherein a material thickness of said second diaphragm becomes gradually thick from a central area towards a peripheral area.

16. The loudspeaker of claim 14, wherein a material thickness of said second diaphragm becomes gradually thin from a central area towards a peripheral area.

17. The loudspeaker of claim 14, wherein said second diaphragm is provided with a groove.

18. A module comprising:

5 an enclosure having an opening provided with a second diaphragm disposed at said opening; at least one sound generator provided with a first diaphragm and coupled acoustically with said enclosure; and a display device disposed at a surface of said enclosure, said surface opposing to said second diaphragm .

15 19. The module of claim 18, wherein an area of said second diaphragm is greater than an area of said first diaphragm.

20. The module of claim 18, wherein both of said second diaphragm and said enclosure are made of a transparent material.

25 21. The module of claim 20, wherein said transparent material is a resin.

22. The module of claim 18, wherein said enclosure and a frame of said sound generator are unitary molded.

30 23. The module of claim 18, wherein said second diaphragm is divided into portions, said portions being connected via a flexible material.

35 24. The module of claim 18, wherein a material thickness of said second diaphragm differs depending on a portion.

25. An electronic apparatus comprising:

40 an enclosure having an opening provided with a second diaphragm disposed at said opening; at least one sound generator provided with a first diaphragm and coupled acoustically with said enclosure; a display device disposed at a surface of said enclosure, said surface opposing to said second diaphragm; and an operation section.

50 26. The electronic apparatus of claim 25, wherein an area of said second diaphragm is greater than an area of said first diaphragm.

27. The electronic apparatus of claim 25, wherein both of said second diaphragm and said enclosure are made of a transparent material.

55 28. The electronic apparatus of claim 27, wherein said transparent material is a resin.

29. The electronic apparatus of claim 25, wherein said enclosure and a frame of said sound generator are unitary molded.

30. The electronic apparatus of claim 25, wherein said second diaphragm is divided into portions, said portions being connected via a flexible material. 5

31. The electronic apparatus of claim 25, wherein a material thickness of said second diaphragm differs depending on a portion. 10

15

20

25

30

35

40

45

50

55

FIG. 1

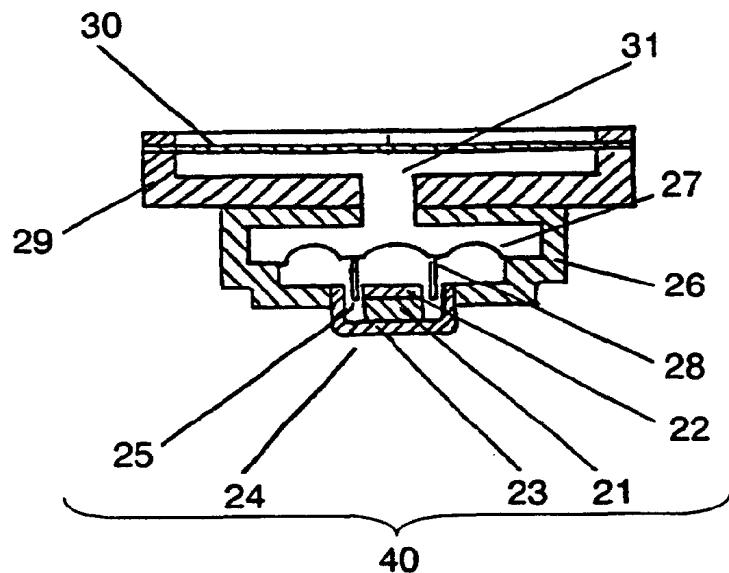


FIG. 2

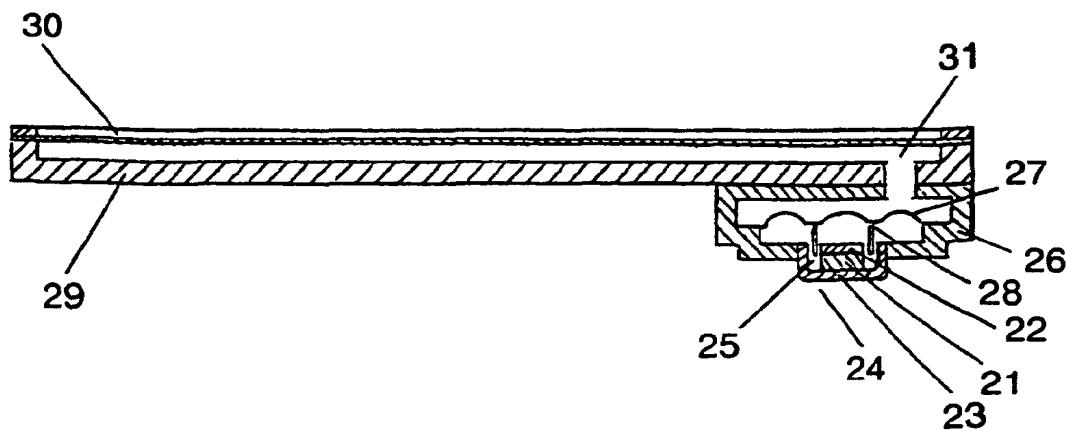


FIG. 3

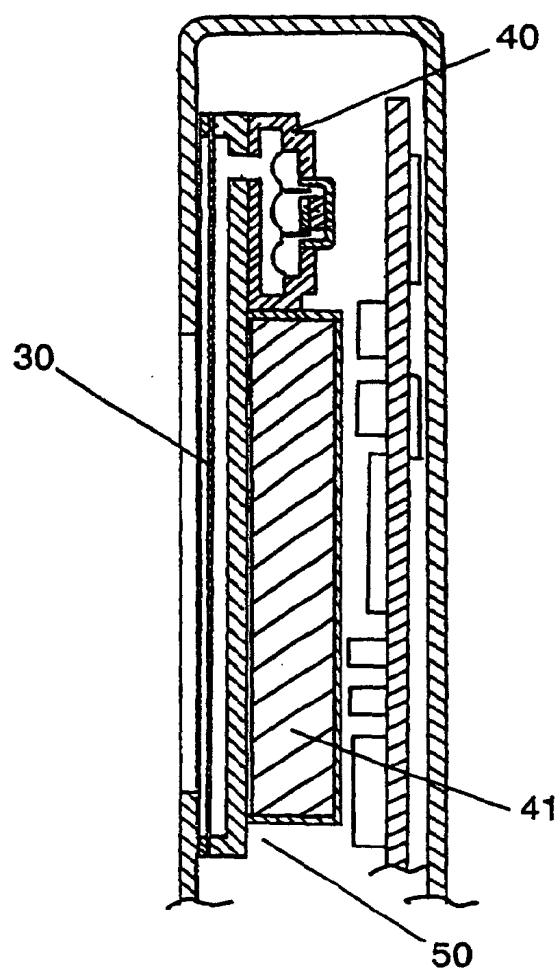


FIG. 4

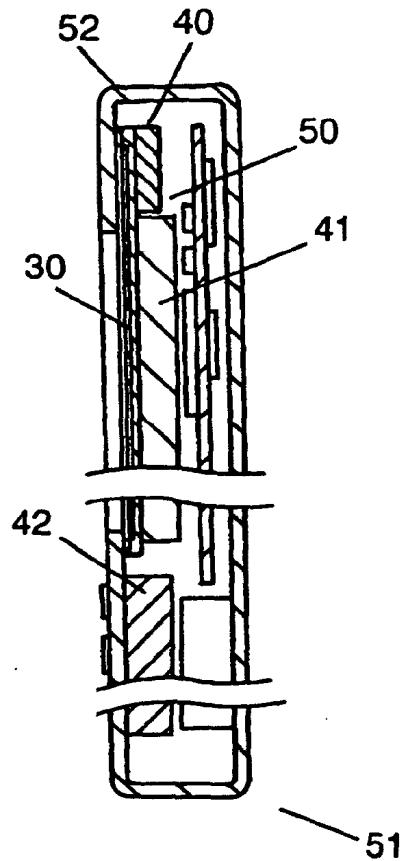


FIG. 5

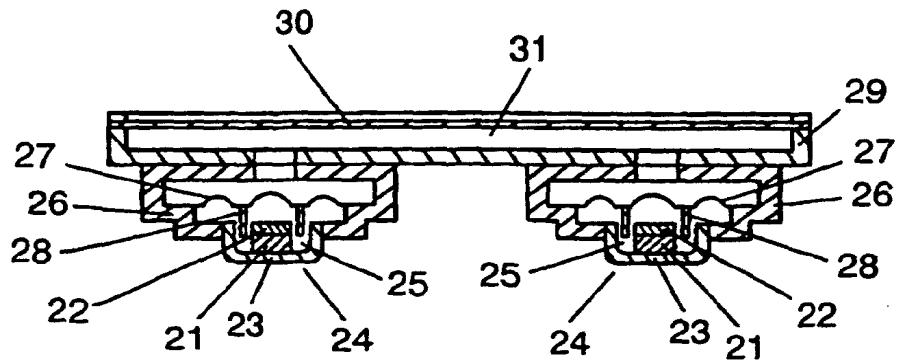


FIG. 6

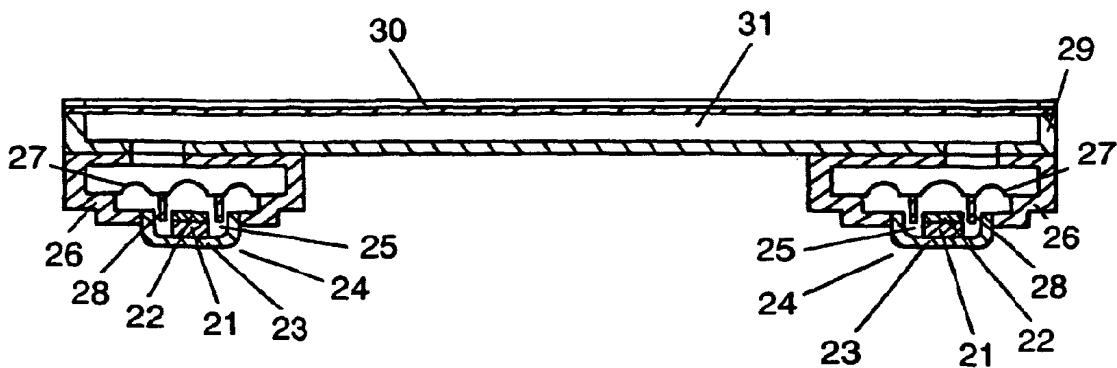


FIG. 7

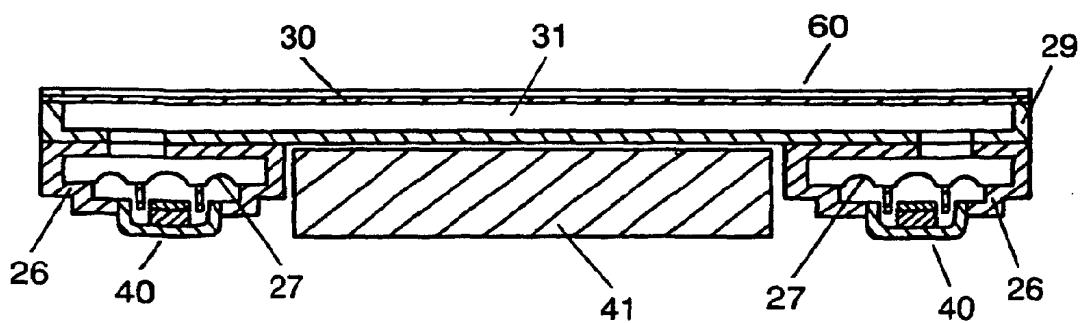


FIG. 8

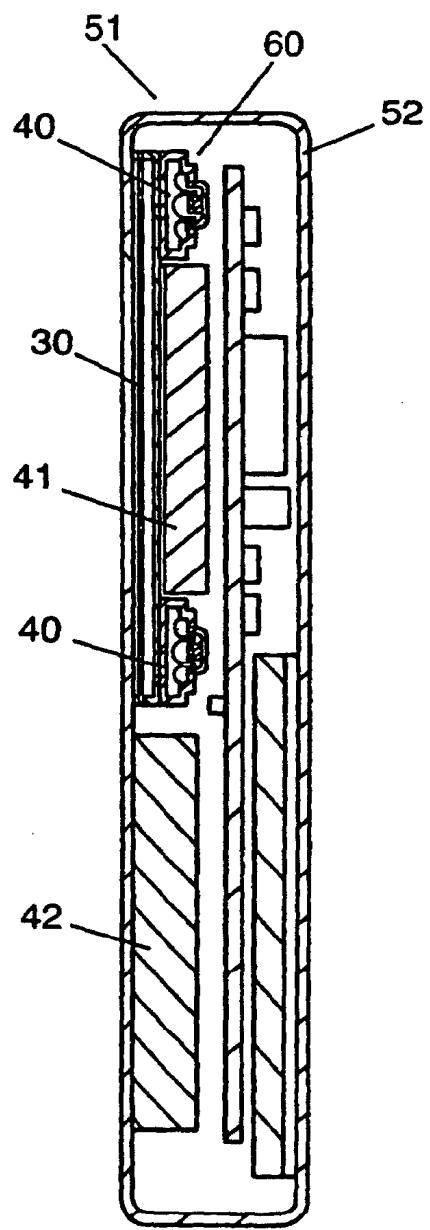


FIG. 9

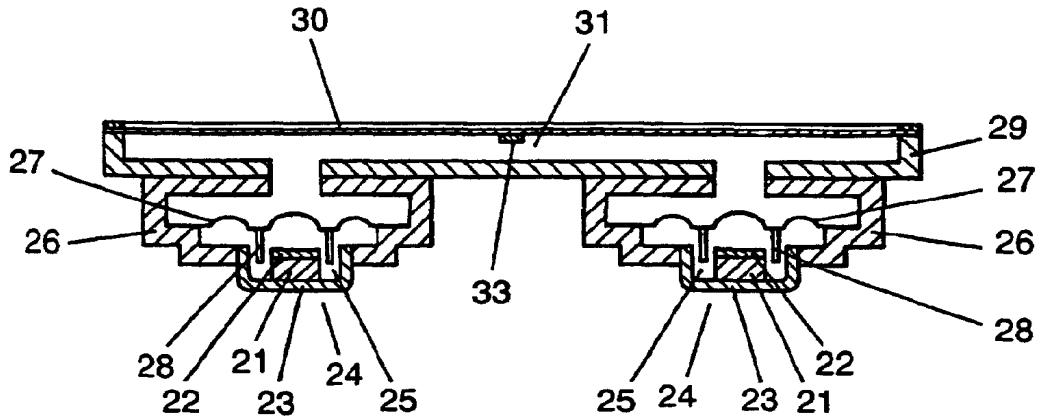


FIG. 10 (a)

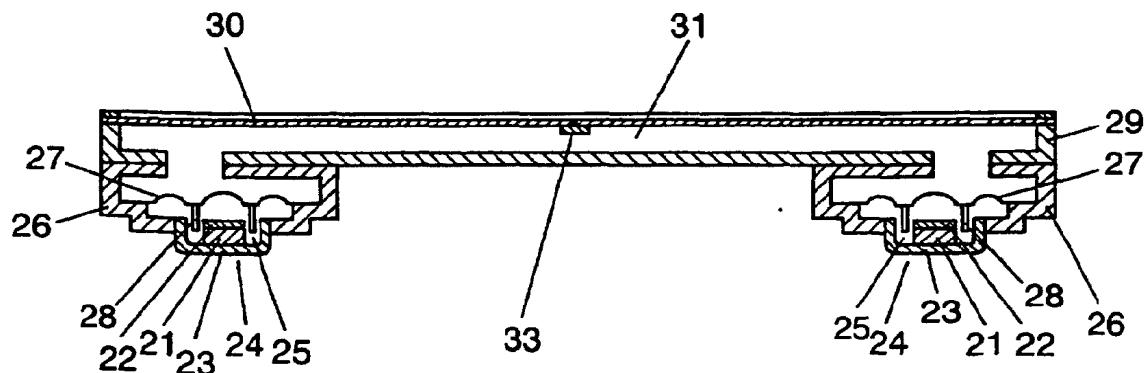


FIG. 10 (b)

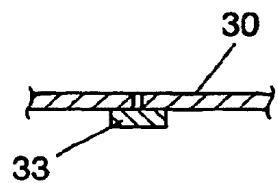


FIG. 11

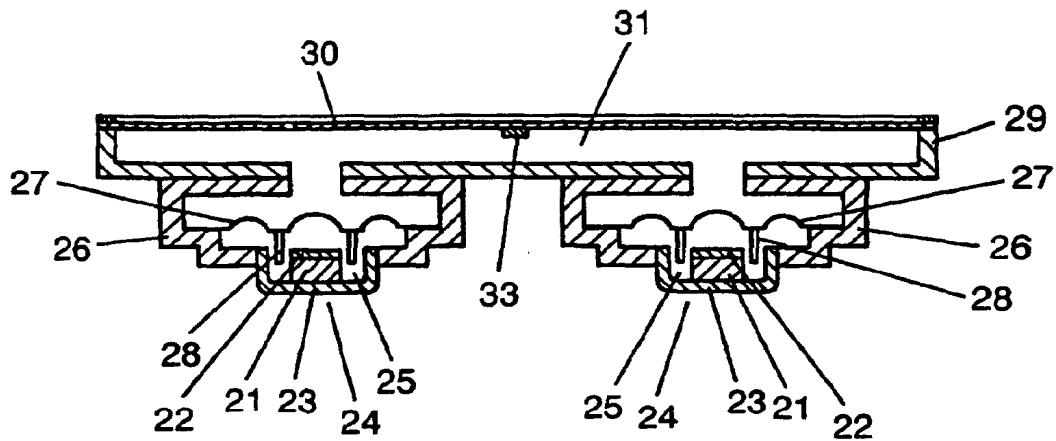


FIG. 12

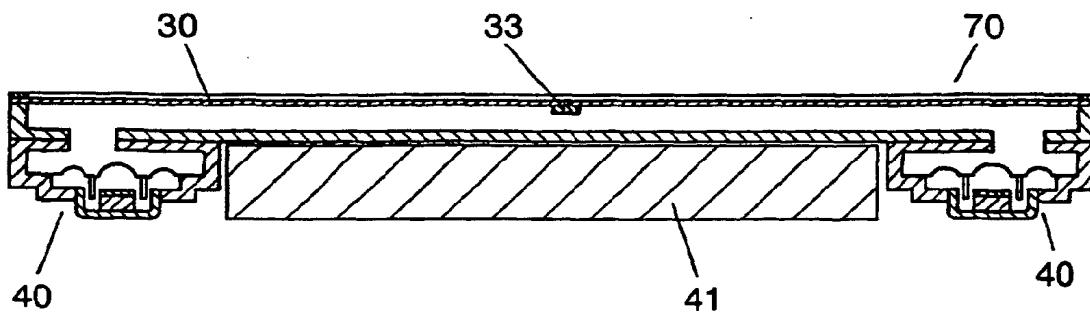


FIG. 13

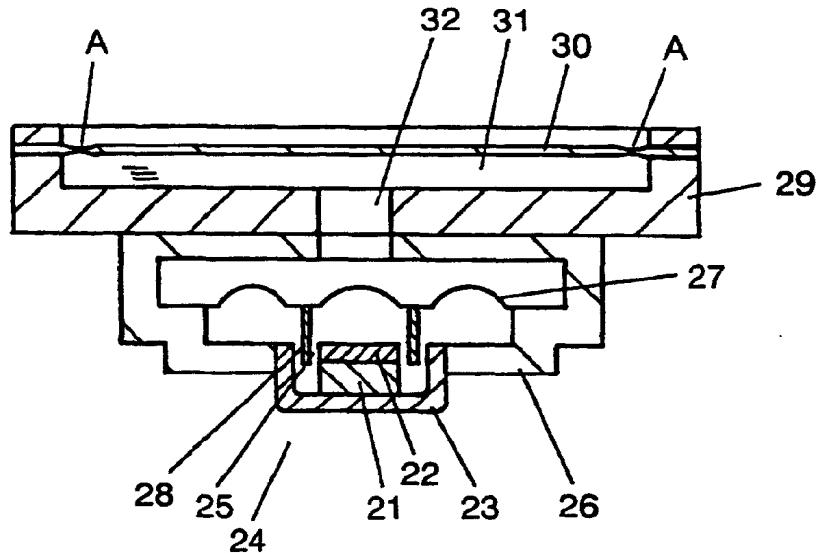


FIG. 14

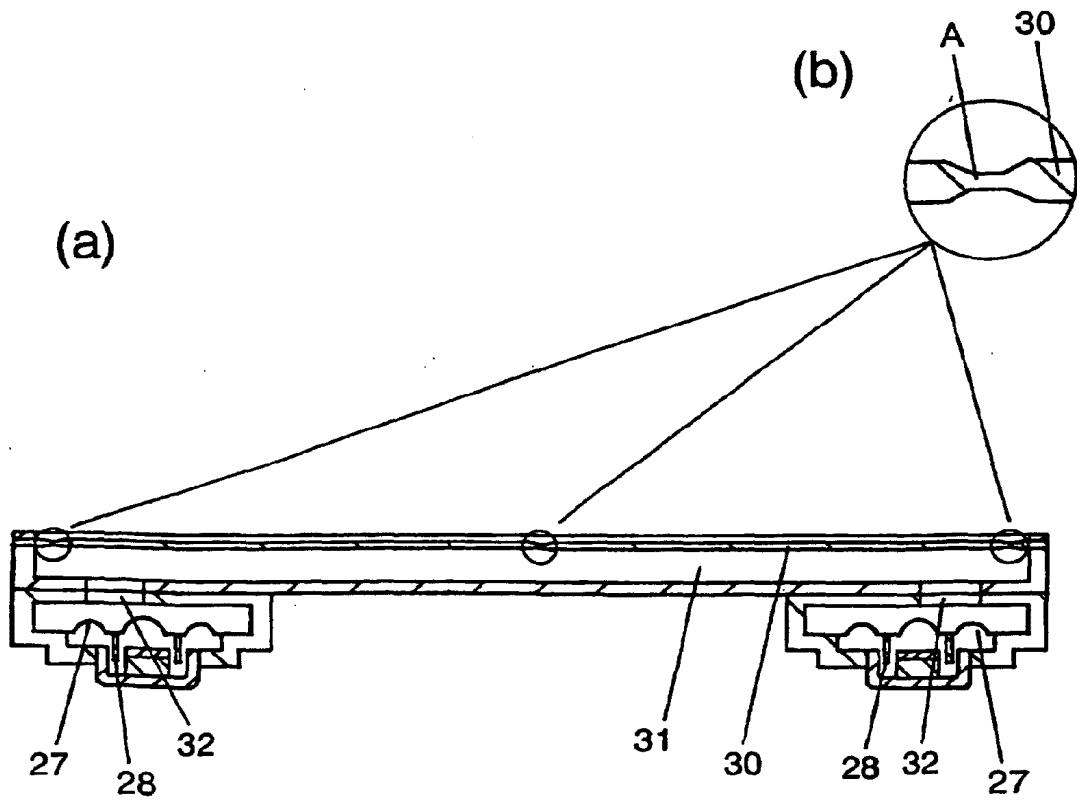


FIG. 15

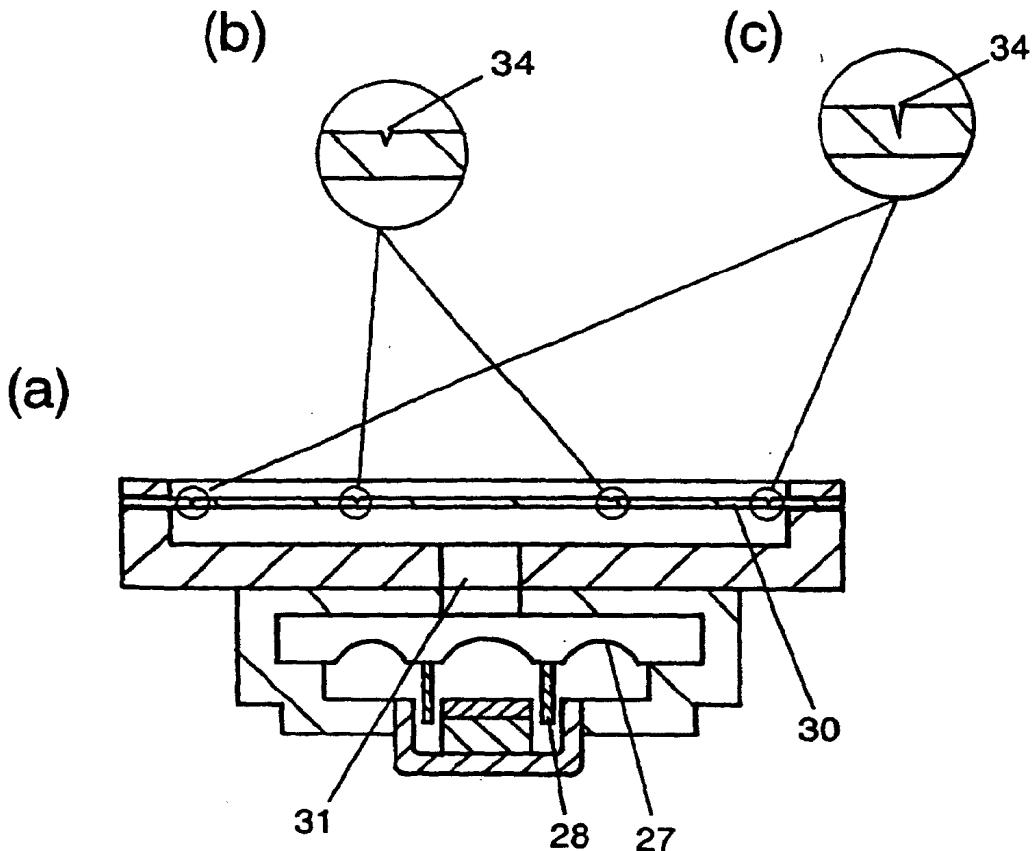


FIG. 16

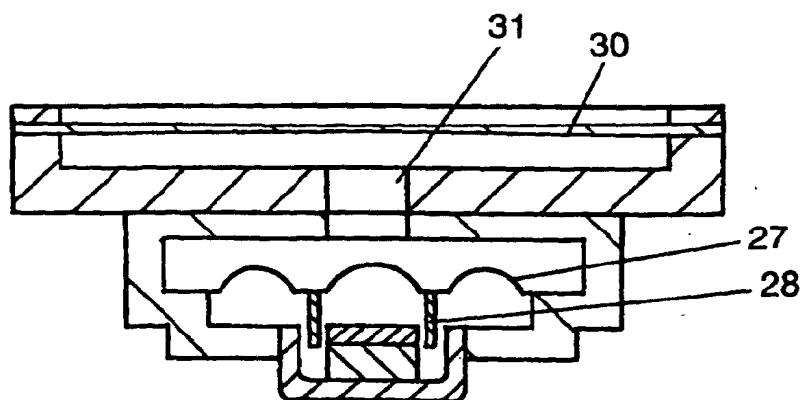


FIG. 17

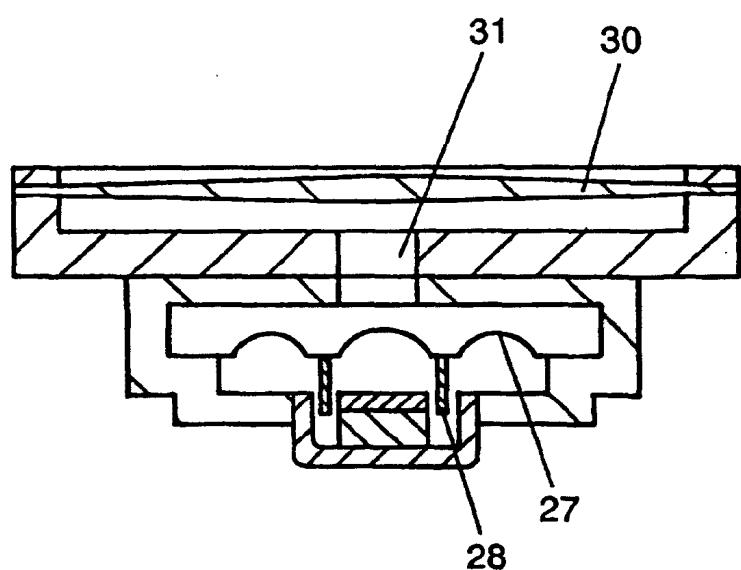


FIG. 18

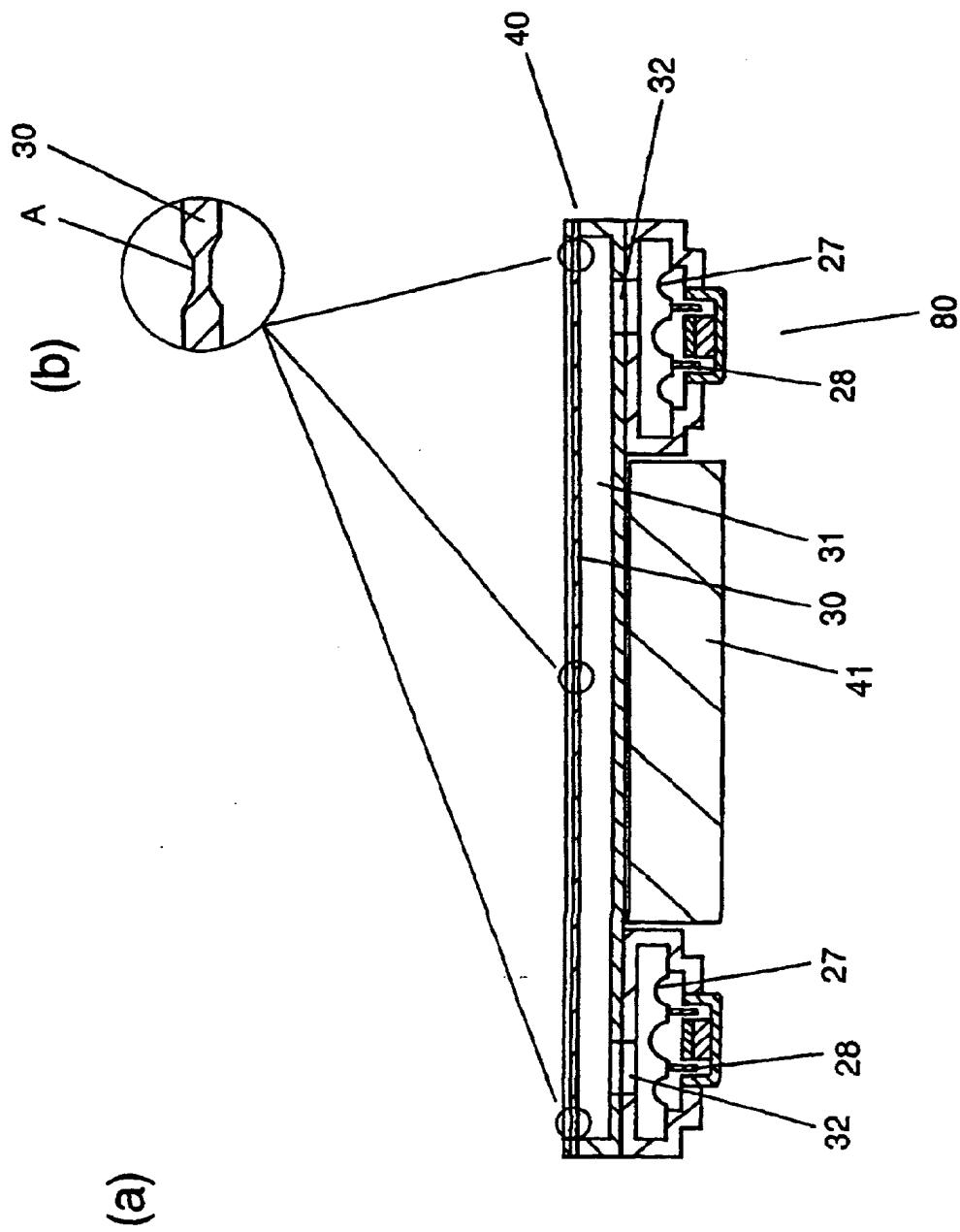


FIG. 19

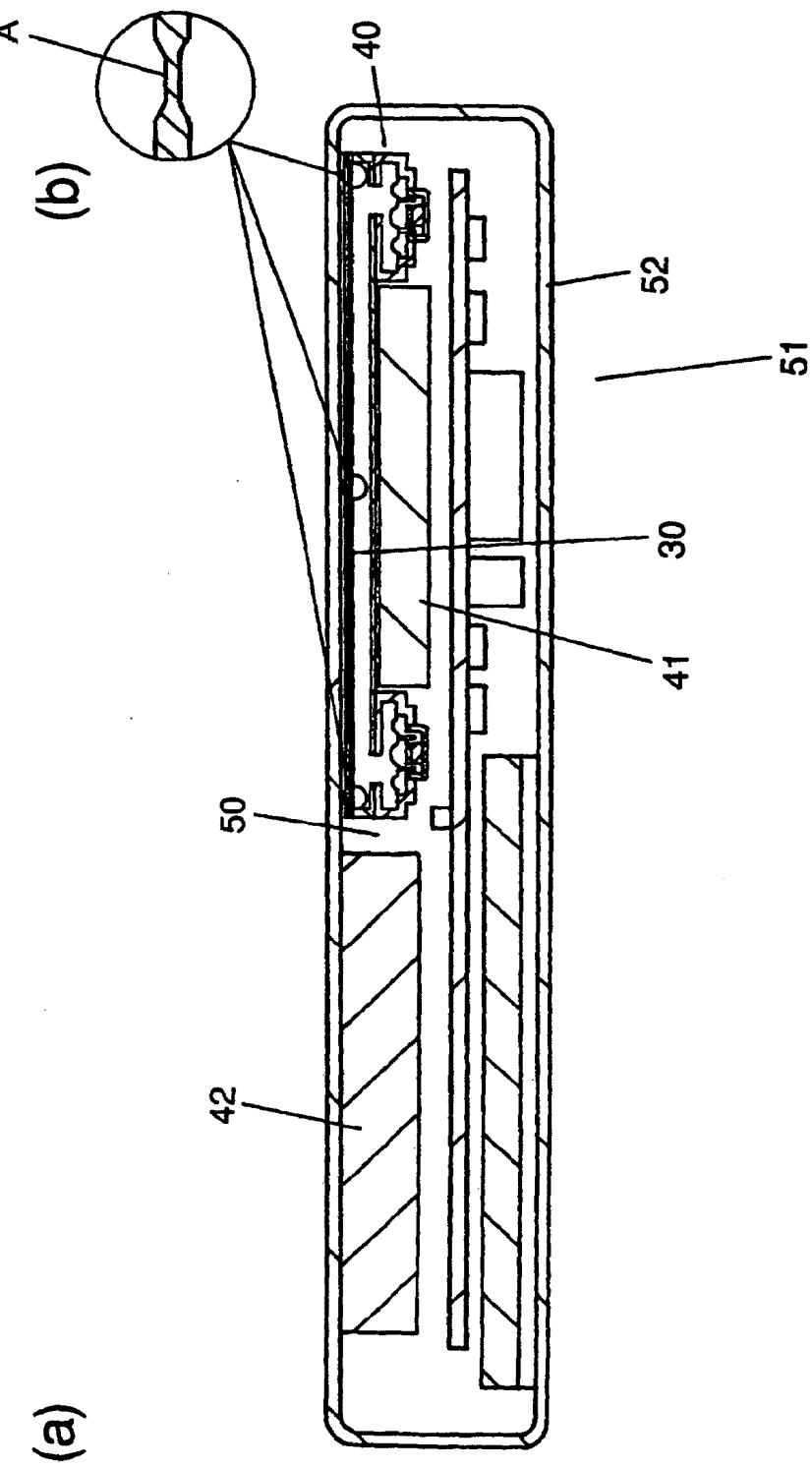


FIG. 20

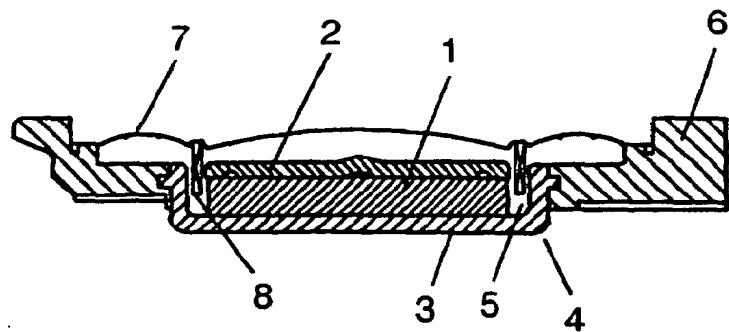


FIG. 21

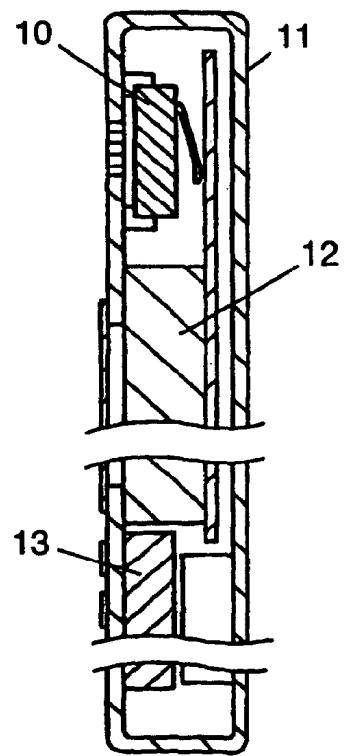
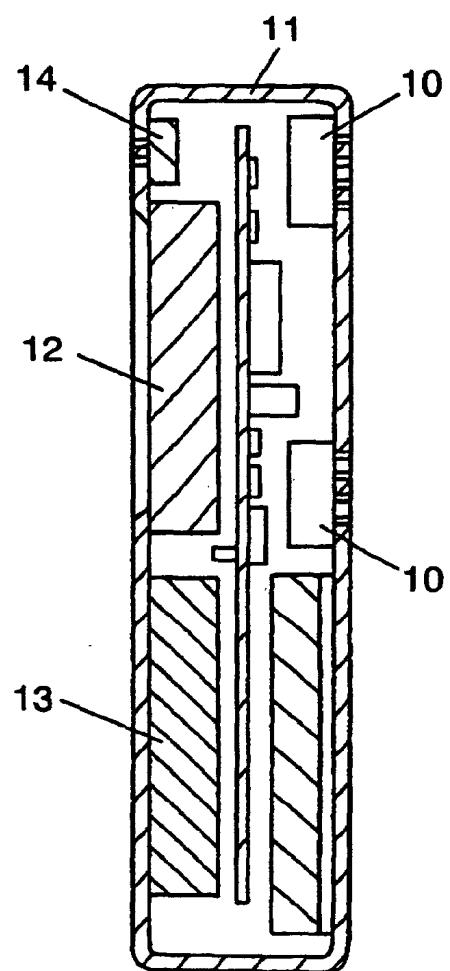


FIG. 22



Reference numerals

- 21 Magnet
- 22 Upper plate
- 23 Yoke
- 24 Magnetic circuit
- 25 Magnetic gap
- 26 Frame
- 27 First diaphragm
- 28 Voice coil
- 29 Box
- 30 Second diaphragm
- 31 Enclosure
- 33 Soft material rich in flexibility
- 34 Groove
- 40 Sound generator
- 41 Display device
- 42 Operation section
- 50 Module
- 51 Portable telephone unit
- 52 Outer case
- 60 Module
- 70 Module
- 80 Module

INTERNATIONAL SEARCH REPORT		International application No. PCT/JP02/09926									
<p>A. CLASSIFICATION OF SUBJECT MATTER Int.Cl⁷ H04R1/28, H04R9/10, H04M1/02, H04M1/03</p> <p>According to International Patent Classification (IPC) or to both national classification and IPC</p>											
<p>B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) Int.Cl⁷ H04R1/28, H04R9/10, H04M1/02, H04M1/03</p>											
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2002 Kokai Jitsuyo Shinan Koho 1971-2002 Jitsuyo Shinan Toroku Koho 1996-2002											
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)											
<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left; padding: 2px;">Category*</th> <th style="text-align: left; padding: 2px;">Citation of document, with indication, where appropriate, of the relevant passages</th> <th style="text-align: left; padding: 2px;">Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td style="text-align: center; padding: 2px;">X</td> <td style="padding: 2px;">Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 73205/1986 (Laid-open No. 186584/1987) (Onkyo Corp.), 27 November, 1987 (27.11.87), Full text; Figs. 1 to 5</td> <td style="text-align: center; padding: 2px;">1-6, 9, 18-19, 22, 25-26, 29</td> </tr> <tr> <td style="text-align: center; padding: 2px;">Y</td> <td style="padding: 2px;">Full text; Figs. 1 to 5 (Family: none)</td> <td style="text-align: center; padding: 2px;">7-8, 10-17, 20-21, 23-24, 27-28, 30-31</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 73205/1986 (Laid-open No. 186584/1987) (Onkyo Corp.), 27 November, 1987 (27.11.87), Full text; Figs. 1 to 5	1-6, 9, 18-19, 22, 25-26, 29	Y	Full text; Figs. 1 to 5 (Family: none)	7-8, 10-17, 20-21, 23-24, 27-28, 30-31
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.									
X	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 73205/1986 (Laid-open No. 186584/1987) (Onkyo Corp.), 27 November, 1987 (27.11.87), Full text; Figs. 1 to 5	1-6, 9, 18-19, 22, 25-26, 29									
Y	Full text; Figs. 1 to 5 (Family: none)	7-8, 10-17, 20-21, 23-24, 27-28, 30-31									
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.											
* Special categories of cited documents: “A” document defining the general state of the art which is not considered to be of particular relevance “E” earlier document but published on or after the international filing date “L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) “O” document referring to an oral disclosure, use, exhibition or other means “P” document published prior to the international filing date but later than the priority date claimed											
“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention “X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone “Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art “&” document member of the same patent family											
Date of the actual completion of the international search 18 October, 2002 (18.10.02)		Date of mailing of the international search report 29 October, 2002 (29.10.02)									
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer									
Facsimile No.		Telephone No.									

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP02/09926

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 24630/1982 (Laid-open No. 127779/1983) (Fujitsu Ten Ltd.), 30 August, 1983 (30.08.83), Full text; Figs. 1 to 3	1-6,9
Y	Full text; Figs. 1 to 3 (Family: none)	7-8,10-31
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 55817/1988 (Laid-open No. 159487/1989) (Foster Electric Co., Ltd.), 06 November, 1989 (06.11.89), Full text; Figs. 1 to 4 (Family: none)	7-8,20-21, 27-28
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 118881/1980 (Laid-open No. 41392/1982) (Onkyo Corp.), 05 March, 1982 (05.03.82), Full text; Fig. 1 (Family: none)	10-11,13,23, 30
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 057681/1980 (Laid-open No. 160086/1981) (Onkyo Corp.), 28 November, 1981 (28.11.81), Full text; Figs. 1 to 3 (Family: none)	10-11,13,23, 30
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 93702/1989 (Laid-open No. 34391/1991) (Onkyo Corp.), 04 April, 1991 (04.04.91), Full text; Figs. 1 to 4 (Family: none)	12
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 078219/1980 (Laid-open No. 2790/1982) (Pioneer Electronic Corp.), 09 January, 1982 (09.01.82), Full text; Figs. 1 to 5 (Family: none)	14-16,24,31
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 035890/1979 (Laid-open No. 135591/1980) (Torio Kabushiki Kaisha), 26 September, 1980 (26.09.80), Full text; Figs. 1 to 4 (Family: none)	17

Form PCT/ISA/210 (continuation of second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP02/09926

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 6-177809 A (Hitachi, Ltd.), 24 June, 1994 (24.06.94), Full text; Figs. 1 to 18 (Family: none)	25

Form PCT/ISA/210 (continuation of second sheet) (July 1998)